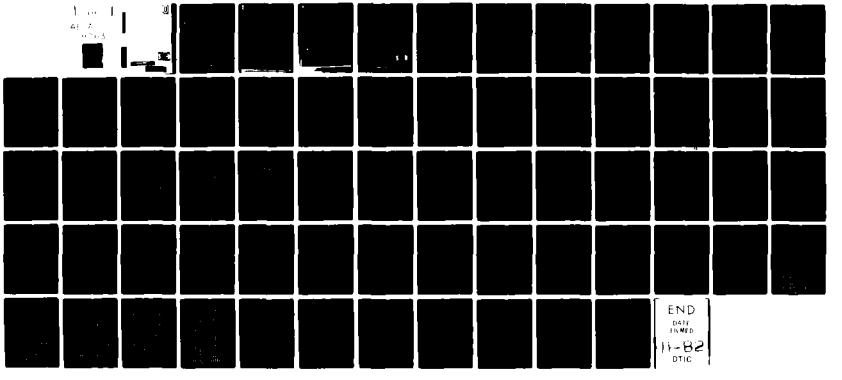
AD-A119 763 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH F/G 13/13
A CORNELL UNIVERSITY LARGE CLASSROOM UTILIZATION STUDY.(U)
MAY 82 D M ARMITAGE, J T FUNG, L L PANGBORN
UNCLASSIFIED AFIT/CI/NR/82-56T NL



UNCLASS

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

ADA 119 763

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFIT/CI/NR/82-56T	2. CATALOG NUMBER
4. TITLE *(and Subtitle)*: A Cornell University Large Classroom Utilization Study	5. TYPE OF REPORT & PERIOD COVERED: THESIS/DISSERTATION
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Linda Louise Pangborn	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: AFIT STUDENT AT: Cornell University	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: AFIT/NR, WPAFB OH 45433	12. REPORT DATE: May 1982
	13. NUMBER OF PAGES: 40
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASS
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

APPROVED FOR PUBLIC RELEASE: IAW AFR 190-17

12 Sept 1982.

LYNN E. WOLAVER
Dean for Research and
Professional Development
AFIT, Wright-Patterson AFB OH

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

ATTACHED

B2

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASS

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

EXECUTIVE SUMMARY

This project seeks to determine if there is a shortage of large classrooms and lecture halls at Cornell. A large classroom, for the purposes of this project, is one with a capacity of 68 or more. A total of 75 rooms at Cornell fit this size description.

Two quantitative measures, the utilization rate and the occupancy rate, provide a basis for the analysis performed in arriving at the results. The utilization rate is the percentage of time a classroom is used. The occupancy rate is the average percentage of seats occupied when a classroom is used. The rates are determined for all 75 rooms using Fall 1981 data. The data consists of sections, days, times and class enrollments for these larger classrooms.

Final results of the analysis indicate there is no physical shortage of large classrooms and lecture halls at Cornell. In fact, the average utilization rate of all rooms is approximately 56%, and the average occupancy rate is only 45%.

However, results do indicate several factors which could account for a perceived shortage. Specifically, the relatively heavy use of the popular time periods (9:05, 10:10, 11:15 and 12:20) indicate that there are a few times when all classrooms of size 300 and above are occupied.

These apparent shortages can be eliminated in all cases by moving one or more classes to a smaller room.

Lack of communication between College Registrars and the Central Registrar, the fact that no accurate data is readily available, and professor classroom and time preferences all contribute to the perception of a shortage.

The study concludes with some recommendations for correcting these problems, and a proposal for further study in the area of efficient classroom scheduling.

A CORNELL UNIVERSITY

LARGE CLASSROOM UTILIZATION STUDY

A Project Report

Presented to the Faculty of the Graduate School

of Cornell University in Partial Fulfillment

of the Requirements for the Degree of

Master of Engineering (Operations Research)

by

David Michael Armitage

Johnny Tak-yuen Fung

Linda Louise Pangborn

May 1982

May 23, 1982

Professor George Nemhauser
Director of School of Engineering
and Operations Research
Upson Hall
Cornell University
Ithaca, NY 14850

Dear Professor Nemhauser:

This project is being presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Master of Engineering (Operations Research).

Initiated by Vice Provost Peter Stein, this project investigates the question "Is there a shortage of large classrooms and lecture halls at Cornell?" The answer is an emphatic "No", as indicated by our analysis.

However, the results expose several underlying problems which may have triggered the initial question. They also reveal several other interesting related topics which, we believe, could be investigated by future Master of Engineering projects.

Sincerely,

David Armitage

Johnny Fung

Linda Pangborn

Linda Pangborn

ACKNOWLEDGEMENTS

First, we would like to thank our advisor, Professor George Nemhauser, for his support, both moral and technical, and for his many excellent suggestions. When we began to stray from the critical issues and founder in unimportant details, he righted our course. Next, thanks to Professor Peter Stein, our client, for his continued interest and support and for his many insights which enabled us to see the big picture we might otherwise have missed. We appreciatively acknowledge the assistance of the University Registrar, Mr. Keith Ickes, and his staff, and of the Space Inventory Manager, Ms. Nikki Reynolds, for the data they provided. A big thank you goes to all the College Registrars, not only for the additional data they provided, but also for their opinions, insights and the benefit of their experience. Finally, this report would have not have been possible without the excellent typing support of Beverly Doolittle.

We dedicate this report to our parents since they actually started it all.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This project seeks to determine if there is a shortage of large classrooms and lecture halls at Cornell. A large classroom, for the purposes of this project, is one with a capacity of 68 or more. A total of 75 rooms at Cornell fit this size description.

Two quantitative measures, the utilization rate and the occupancy rate, provide a basis for the analysis performed in arriving at the results. The utilization rate is the percentage of time a classroom is used. The occupancy rate is the average percentage of seats occupied when a classroom is used. The rates are determined for all 75 rooms using Fall 1981 data. The data consists of sections, days, times and class enrollments for these larger classrooms.

Final results of the analysis indicate there is no physical shortage of large classrooms and lecture halls at Cornell. In fact, the average utilization rate of all rooms is approximately 56%, and the average occupancy rate is only 45%.

However, results do indicate several factors which could account for a perceived shortage. Specifically, the relatively heavy use of the popular time periods (9:05, 10:10, 11:15 and 12:20) indicate that there are a few times when all classrooms of size 300 and above are occupied.

These apparent shortages can be eliminated in all cases by moving one or more classes to a smaller room.

Lack of communication between College Registrars and the Central Registrar, the fact that no accurate data is readily available, and professor classroom and time preferences all contribute to the perception of a shortage.

The study concludes with some recommendations for correcting these problems, and a proposal for further study in the area of efficient classroom scheduling.

I. INTRODUCTION

This project investigates an alleged common perception that there exists a shortage of large classrooms and lecture halls at Cornell. The project's primary objective is to determine whether there is a factual basis for this perception and to recommend some solution to the shortage if one exists. If no shortage is apparent, the project attempts to determine reasons for the error and to provide solutions and recommendations that might help prevent further misconceptions.

This paper describes the several steps which comprise the project, including problem definition, initial decisions and assumptions, data collection and analysis, (and problems therein encountered), and results and conclusions.

Each of these areas will be addressed in turn, with greatest emphasis being placed on the data collection and analysis phases, and presentation of results. These are not only the most crucial phases, but also the most time consuming and problem-ridden, justifying the increased discussion.

II. PROBLEM DEFINITION

The basic question to be answered, at least initially, is: "Is there a shortage of large classrooms and lecture halls at Cornell?"

To investigate this question, it is first necessary to define some quantitative measure(s) so as to reduce the need for subjective judgments concerning shortages. Thus, two performance measures are defined here for the purposes of analysis. The first is utilization rate. Utilization rate refers to how often a particular classroom is used out of the total periods when it is available for use. (Normally 8 A.M. to 4 P.M., Monday through Friday). It is usually expressed in percentage. The second, occupancy rates, tells how full a given classroom is, on average, when it is being used. This too, is normally expressed in percentage.

More specifically, the utilization and occupancy rates are defined as follows.

$$\text{Utilization Rate} = \frac{\text{Number of class periods used}}{\text{Total Number of class periods}}$$

There are a total of 40 class periods for each classroom during a week. Each period is a particular class time on a particular day. Thus 8:00 on Monday and 10:10 on Tuesday are examples of class periods.

$$\text{Occupancy Rate} = \frac{\text{Average Section Size}}{\text{Classroom Capacity}}$$

The average section size is the total enrollment of all courses scheduled in a particular room divided by the total number of sections scheduled in that room.

In addition, to define the problem completely, it is necessary to specify what constitutes a large classroom. For the purposes of this project, a large classroom is defined to be one with a capacity of 68 or greater. The rationale for choosing this minimum cut off point is provided in the section dealing with data collection. With the problem now quantitatively defined, the framework for project accomplishment is outlined by the assumptions listed in the following section.

III. ASSUMPTIONS

The following assumptions concerning the constraints on and parameters of the problem are made prior to any analysis:

(1) Assume no growth in overall university enrollment over the next ten years.

(2) Assume no change in size relationships among colleges.

(3) 100% occupancy rates are both unrealistic and undesirable. A figure of 80% shall constitute full occupancy.

(4) Scheduling responsibilities should remain with individual college registrars, unless the data indicates that substantial benefits might be realized by centralizing scheduling procedures.

IV. APPROACH

To investigate the question of "Is there a shortage of large classrooms at Cornell", the starting point must be the definition of a large classroom. While it is tempting to choose arbitrarily as a minimum classroom size one that sounds large, say 100 or more, a more objective cut-off point can be determined. If the criteria are 1) The smallest-sized room that is used primarily for lectures rather than recitations, and 2) A room size where there exists a "natural break" or large gap in the room capacity rankings, the definition of a large classroom at Cornell becomes one with a capacity of 68 or greater.

This definition established, the next task is to identify, by name and number, the large classrooms. This information should be available on the Cornell Space Inventory File, maintained by the Cornell Division of Facilities and Business Operations. However, the information available on this file, which includes room name and number, room type, seating type and room capacity, is not fully accurate. Some rooms are included on the file that no longer exist, some rooms are not on the file that do exist, and some rooms are identified by names or numbers different from the room's actual designation. ("Actual" means the designation given the classroom by the registrar for the

college with jurisdiction over the room.) Also, many room capacities as listed on the file differ from registrar records. A physical investigation of large rooms on campus and discussion with college registrars is necessary to sort out the inaccuracies and create an exact listing of large classrooms and their capacities. This list of 75 classrooms is shown in Table I of Appendix A. An asterisk beside the room number indicates that an error of some sort exists in either or both the Space Inventory File or Registrar's File for that classroom.

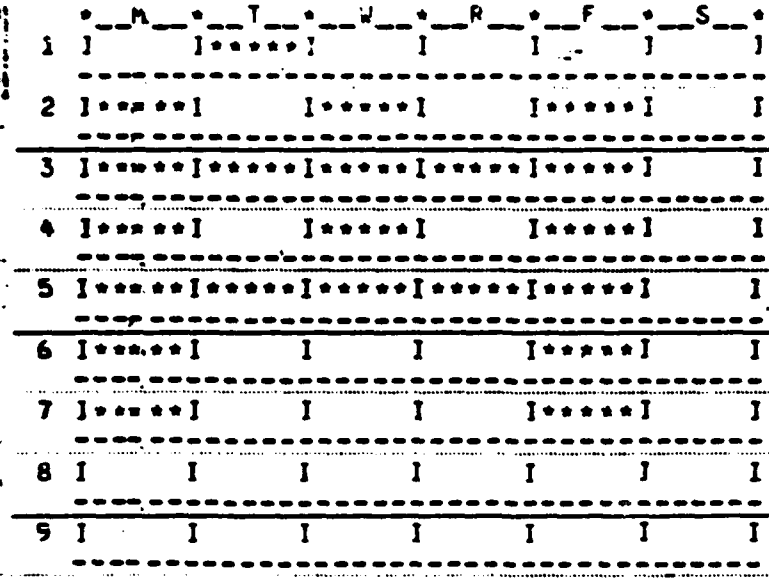
The Registrar's File lists, among other things, college, section, course number, room assignment, time, day and enrollment for each section or class scheduled to be taught at Cornell. This file also contains many errors. Often, enrollments are inaccurate or omitted and some room designations do not correspond with individual college registrar's records. The use of this file requires correcting the enrollment figures by consulting with college registrars and matching the room names and numbers to registrar's listings.

Once both files are corrected, they must be merged to compare class enrollments with classroom capacities. This also presents some difficulties. The major problem is that the central registrar's file is written in free format and is not computer readable. After re-structuring the registrar's

file by installing a coding system to make the file computer accessible, the merger can be accomplished. A computer program that extracts information from the new merged file, re-structures it, and prints it out in a matrix format is presented in Appendix B. The output of this program is a series of matrices, one for every large classroom. An example of the output can be seen in Figure I on the following page. The rows and columns in each matrix represent time (by scheduling period) and day, respectively. Thus each entry is an available class period for that room. If there is a starred entry, then the classroom is being used, and if not, then it is empty.

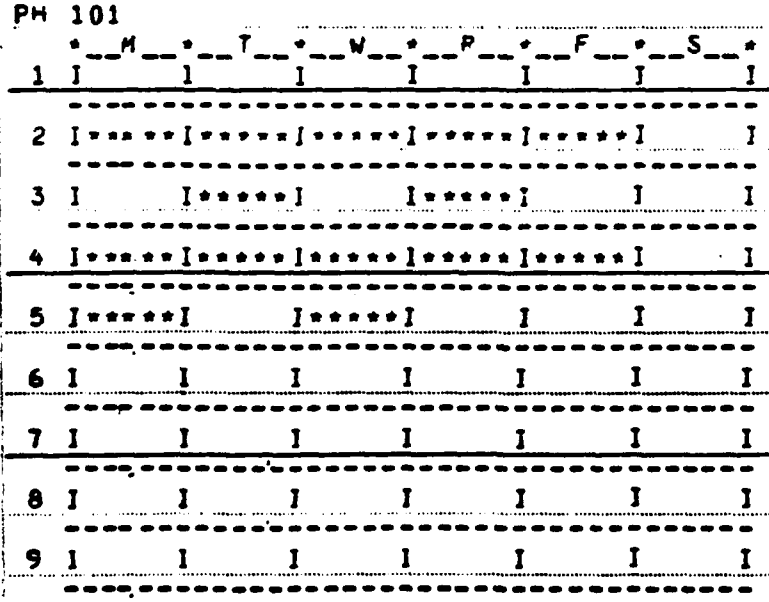
Using the information derived from these matrices, utilization rates can be determined. Each room's utilization rate is computed and printed out under its matrix. Also, using class enrollments and room capacities, occupancy rates can be calculated. Again, utilization is the percentage of possible time (8:00 to 4:00 Monday through Friday) that a classroom is used. Occupancy is the percentage of a room's seats that are filled by an average-sized class. (Average size is determined by summing the enrollments of all sections scheduled in a particular class, then dividing by the number of sections.) Occupancy rates for the large classrooms are also computed and printed alongside the utilization figures.

UPB-17



ROOM_UTI(12)= 2.10000E+01 OCCU_RATE(12)= 4.07834E-01;

PH 101



ROOM_UTI(13)= 2.20000E+01 OCCU_RATE(13)= 3.79186E-01;

FIGURE I MATRIX FORMAT PRINTOUT

EXAMPLE

In order to ascertain whether or not local problems exist, it is necessary to further divide the university's large classrooms into groups by size. Separation into five divisions or groups allows investigation of shortages in more specifically identified classrooms. Now, questions of usage and occupancy can be answered for rooms of capacity 400 and up, 300 to 350, 200 to 265, 125 to 196 and 68 to 117. Another sub-division is made to identify problems in individual locations on campus. Rather than dividing the university by college, it was felt that some colleges were in such close proximity to each other, so as to not need distinction. Thus, the university is divided into three locations each representing an area in which classrooms could be shared for scheduling purposes without requiring unnecessarily long distances to be walked by professors and students in-between classes. These locations, mapped in Figure II are Arts & Sciences and Architecture, Engineering, Hotel and Industrial/Labor Relations, and Agriculture and Human Ecology. Table II, Room Breakdown, shows the number of large classrooms that fall into each category by size group and location. (See pages 10 and 11 .)

It is noted here that the professional schools, Law and Business and Public Administration, are omitted

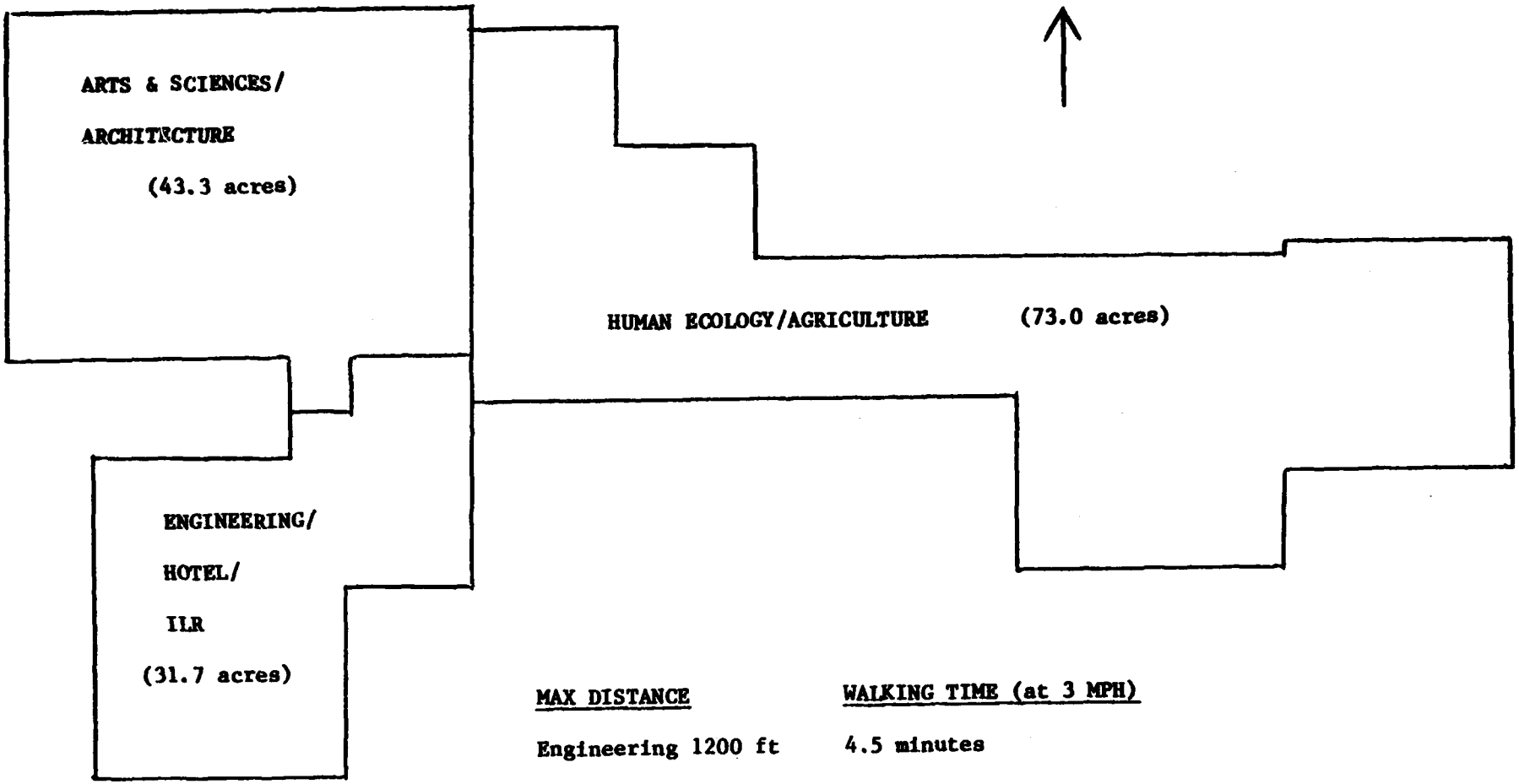
from this study. This is done under the mistaken impression that they are separate entities at the university and could not participate in any sharing of classroom space. This, in fact, is not the case. However, inclusion of these two schools and their associated large classrooms would only serve to enlarge the available space and fortify the conclusions made.

V. DATA ANALYSIS

Detailed data analysis was carried out for a typical Monday and a typical Tuesday. Since classes are normally scheduled on a Monday - Wednesday - Friday or Tuesday - Thursday basis, classroom utilization within each of those two groupings is very similar. In fact, the slight utilization differences that do exist within the groupings, indicate that room utilization is greater during the earlier part of the week. Therefore, the Monday and Tuesday data represent the "maximum classroom use" situation. These conclusions may be verified by examining the "dot charts", Tables III thru VII in Appendix A. Consolidated from the computer data listing, these charts use dots to indicate, by period for each room, the times when a class is scheduled. There is a separate dot chart for each day of the week.

Utilization rates are then examined by groups, as defined earlier. Each of the five groups contains classrooms

FIGURE II



MAX DISTANCE		WALKING TIME (at 3 MPH)
Engineering	1200 ft	4.5 minutes
A & S	1400 ft	5.3 minutes
Agric.	3300 ft	12.5 minutes

0 500 1000

DISTANCE (FT)

TABLE II

ROOM BREAKDOWN

LOCATION GROUP / SIZE GROUP	ARTS & SCIENCE AND ARCH.	AGRIC. AND HUMAN EC.	ENG AND HOTEL AND ILR	TOTAL
GROUP 1 400 - up	3	0	1	4
GROUP 2 300-350	0	4	1	5
GROUP 3 200-265	5	3	6	14
GROUP 4 125-196	2	4	5	11
GROUP 5 68-117	14	16	11	41
TOTAL	25	27	24	75

LARGE ROOM = cap 68 or more

with capacities falling within a selected range. While any grouping is necessarily arbitrary, the one used here is selected so that it maintains a comparable capacity range for each group. This grouping also emphasizes the much smaller number of rooms in the higher capacity categories.

Table VIII gives a breakdown of the percent (and number) of rooms available (empty) in each group at each time period for a typical Monday. (Fraction empty equals one minus the utilization rate.) Table IX gives the same information for a typical Tuesday. See pages 13 and 14. The first apparent indications of a shortage are the three zero entries in the Monday table and the two zero entries in the Tuesday table. However, the tables also indicate possible solutions to these shortage problems.

Most significantly, when occupancy rates are examined, it can be seen that <u>in every case</u> where there appears to be no spare large classrooms, at least one section occupying a large classroom is small enough to be shifted to an available smaller room, usually within the same college and always within the same location group, thus freeing a large classroom. Next, in each case there is at least one room in the same size group available in an immediately adjacent time period on the same day. Often

TABLE VIII
13

ROOMS AVAILABLE (BY PERIOD & GROUP)

MONDAY

	1 8:00	2 9:05	3 10:10	4 11:15	5 12:20	6 1:25	7 2:30	8 3:35
GROUP 1	75 / 3	25 / 1	0 / 0	25 / 1	0 / 0	75 / 3	75 / 3	100 / 4
GROUP 2	60 / 3	0 / 0	40 / 2	20 / 1	40 / 2	80 / 4	100 / 5	100 / 5
GROUP 3	93 / 13	36 / 5	21 / 3	36 / 5	36 / 5	71 / 10	79 / 11	86 / 12
GROUP 4	82 / 9	27 / 3	9 / 1	27 / 3	36 / 4	27 / 3	73 / 8	73 / 8
GROUP 5	80 / 33	27 / 11	27 / 11	24 / 10	56 / 23	41 / 17	49 / 20	59 / 24

GROUP 1: cap. 400-up 4 Rooms
GROUP 2: cap. 300-350 5 Rooms
GROUP 3: cap. 200-265 14 Rooms
GROUP 4: cap. 125-196 11 Rooms
GROUP 5: cap. 68-117 41 Rooms

KEY:

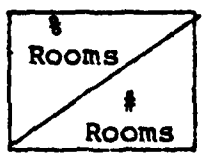


TABLE IX

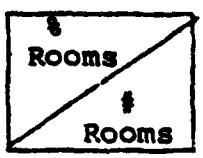
ROOMS AVAILABLE (BY PERIOD & GROUP)

TUESDAY

	1 8:00	2 9:05	3 10:10	4 11:15	5 12:20	6 1:25	7 2:30	8 3:35
GROUP 1	100 / 4	0 / 0	75 / 3	0 / 0	75 / 3	100 / 4	50 / 2	75 / 3
GROUP 2	100 / 5	40 / 2	20 / 1	20 / 1	100 / 5	100 / 5	80 / 4	100 / 5
GROUP 3	86 / 12	50 / 7	43 / 6	50 / 7	57 / 8	71 / 10	93 / 13	93 / 13
GROUP 4	64 / 7	45 / 5	55 / 6	18 / 2	36 / 4	36 / 4	36 / 4	45 / 5
GROUP 5	54 / 22	36 / 14	27 / 11	22 / 9	49 / 20	54 / 22	39 / 16	51 / 21

GROUP 1: cap. 400-up 4 Rooms
GROUP 2: cap. 300-350 5 Rooms
GROUP 3: cap. 200-265 14 Rooms
GROUP 4: cap. 125-196 11 Rooms
GROUP 5: cap. 68-117 41 Rooms

KEY:



several rooms are available. Finally, there is at least one empty room in the same period and same group size on Tuesday, for Monday's zero entries, and on Monday, for Tuesday's zero entries. Therefore, with very little inconvenience or adjustment, additional classes in the fully utilized classroom groups could be accommodated.

Tables X through XV on pages 16 thru 21 take an even closer look at utilization rates when broken down by location. The location groupings again, with their associated colleges, are Arts & Sciences and Architecture, Engineering, Hotel and ILR, and Agriculture and Human Ecology. Capacity Groups 1 and 2 are combined in the tables, as are Capacity Groups 3 and 4. This is done because of the small numbers of rooms in the larger capacity groups, when the rooms are divided by college.

Again, all the zero entries (indicating no rooms empty) are examined. The results of this examination of each of the ten zero entries are given in Table XVI on pages 22 thru 25. For each of the location groupings, the Table shows which capacity group has a zero entry (no rooms available), on which day and in which time period. It also lists each room in the particular capacity group and the enrollment size of the class occupying that room

TABLE X

ROOMS AVAILABLE: ARTS & SCIENCE - ARCHITECTURE

BY PERIOD & GROUP

MONDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	10:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	84 / 21	28 / 7	24 / 6	20 / 5	44 / 11	56 / 14	72 / 18	84 / 21
GROUPS 1&2	67 / 2	33 / 1	0 / 0	33 / 1	0 / 0	67 / 2	67 / 2	100 / 3
GROUPS 3&4	86 / 6	29 / 2	14 / 1	29 / 2	43 / 3	71 / 5	71 / 5	71 / 5
GROUP 5	86 / 12	27 / 4	29 / 4	14 / 2	57 / 8	50 / 7	71 / 10	86 / 12

TOTAL NUMBER OF ROOMS: 25

GROUPS 1&2 : 3

GROUPS 3&4 : 7

GROUP 5 : 14

KEY:

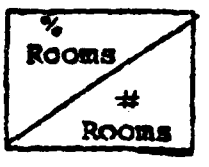


TABLE XI

ROOMS AVAILABLE: ARTS & SCIENCE ~ ARCHITECTURE

BY PERIOD & GROUP

TUESDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	I0:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	68 / 17	32 / 8	28 / 7	20 / 5	28 / 7	64 / 16	36 / 9	52 / 13
GROUPS 1&2	100 / 3	0 / 0	67 / 2	0 / 0	67 / 2	100 / 3	33 / 1	67 / 2
GROUPS 3&4	100 / 7	57 / 4	57 / 4	29 / 2	29 / 2	57 / 4	57 / 4	57 / 4
GROUP 5	43 / 6	21 / 3	7 / 1	21 / 3	14 / 2	57 / 8	29 / 4	50 / 7

ROOMS AVAILABLE: ENGINEERING - HOTEL - ILR

BY PERIOD & GROUP

MONDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	10:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	96 / 23	21 / 5	13 / 3	17 / 4	33 / 8	33 / 8	50 / 12	63 / 15
GROUPS 1&2	100 / 2	0 / 0	0 / 0	0 / 0	0 / 0	100 / 2	100 / 2	100 / 2
GROUPS 3&4	100 / 11	18 / 2	9 / 1	18 / 2	18 / 2	27 / 3	73 / 8	82 / 9
GROUP 5	91 / 10	27 / 3	18 / 2	18 / 2	55 / 6	27 / 3	18 / 2	36 / 4

TOTAL NUMBER OF ROOMS: 24

GROUPS 1&2 : 2

GROUPS 3&4 : 11

GROUP 5: 11

KEY:

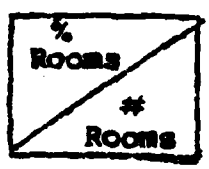


TABLE XIII

ROOMS AVAILABLE: ENGINEERING - HOTEL - ILR

BY PERIOD & GROUP

TUESDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	10:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	50 / 12	38 / 9	42 / 10	29 / 7	63 / 15	58 / 14	54 / 13	63 / 15
GROUPS 1&2	100 / 2	50 / 1	50 / 1	50 / 1	100 / 2	100 / 2	100 / 2	100 / 2
GROUPS 3&4	64 / 7	45 / 5	36 / 4	45 / 5	64 / 7	55 / 6	64 / 7	73 / 8
GROUP 5	27 / 3	27 / 3	45 / 5	9 / 1	55 / 6	55 / 6	36 / 4	45 / 5

ROOMS AVAILABLE: AGRICULTURE - HUMAN ECOLOGY

BY PERIOD & GROUP

MONDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	10:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	63 / 17	30 / 8	30 / 8	41 / 11	56 / 15	56 / 15	67 / 18	70 / 19
GROUPS 1&2	50 / 2	0 / 0	50 / 2	25 / 1	50 / 2	75 / 3	100 / 4	100 / 4
GROUPS 3&4	57 / 4	57 / 4	14 / 1	57 / 4	57 / 4	71 / 5	86 / 6	100 / 7
GROUP 5	69 / 11	25 / 4	31 / 5	38 / 6	56 / 9	44 / 7	50 / 8	50 / 8

TOTAL NUMBER OF ROOMS: 27

GROUPS 1&2 : 4

GROUPS 3&4 : 7

GROUP 5 : 16

KEY:

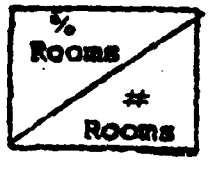


TABLE XV

ROOMS AVAILABLE: AGRICULTURE - HUMAN ECOLOGY

BY PERIOD & GROUP

TUESDAY

	1	2	3	4	5	6	7	8
	8:00	9:05	10:10	11:15	12:20	1:25	2:30	3:35
TOTAL ALL GROUPS	74 / 20	37 / 10	33 / 9	19 / 5	74 / 20	56 / 15	63 / 17	67 / 18
GROUPS 1&2	100 / 4	25 / 1	25 / 1	0 / 0	100 / 4	100 / 4	75 / 3	100 / 4
GROUPS 3&4	71 / 5	43 / 3	57 / 4	29 / 2	57 / 4	57 / 4	86 / 6	86 / 6
GROUP 5	69 / 11	38 / 6	25 / 4	19 / 3	75 / 12	44 / 7	50 / 8	50 / 8

LOCATION GROUP: ARTS AND SCIENCE AND ARCHITECTURE

CAPACITY GROUPS: 1&2 ROOMS: RF A, UH G1, BR 200

MONDAY

1. Zero Entry at 10:10

Room	Class Enrollment	Alternative Location
RF A	140	RF B cap 206 (Same college)
UH G1	322	0
BE 200	400	0

2. Zero Entry at 12:20

Room	Class Enrollment	Alternative Location
RF A	140	RF B cap 206 (Same college)
UH G1	303	0
BR 200	179	GS KAU cap 217 (Same college)

TUESDAY

3. Zero Entry at 9:05

Room	Class Enrollment	Alternative Location
RF A	240	SN G25 cap 265 (Same college)*
UH G1	413	0
BR 200	377	0

4. Zero Entry at 11:15

Room	Class Enrollment	Alternative Location
RF A	240	0
UH G1	345	0
BR 200	213	SH G25 cap 265 (Same college)

* This is a feasible alternative. However, note that the room would be approximately 90% occupied. This high an occupancy rate exceeds the chosen 80% occupied definition of "full", but occasional violations of the 80% rule should be acceptable.

LOCATION GROUP: AGRICULTURE AND HUMAN ECOLOGY

CAPACITY GROUPS: 1&2 ROOMS: VR 167, PS 233, WN 45, MN 146

MONDAY

5. Zero Entry at 9:05

Room	Class Enrollment	Alternative Location
VR 167	242	0
PS 233	379	0
WN 45	281	0
MN 146	86	WN 145 cap 112 (Same college)

TUESDAY

6. Zero Entry at 11:15

Room	Class Enrollment	Alternative Location
VR 167	47	MN 167 cap 75
PS 233	144	RR 125 cap 200 (Same college)
WN 45	103	0
MN 146	123	0

LOCATION GROUP: ENGINEERING, HOTEL AND ILR

CAPACITY GROUPS: 1&2 ROOMS: IV 120, OH 155

MONDAY

7. Zero Entry at 9:05

Room	Class Enrollment	Alternative Location
IV 120	384	0
OH 155	162	IV 110 cap 192**

8. Zero Entry at 10:10

Room	Class Enrollment	Alternative Location
IV 120	338	0
OH 155	102	SR 434 cap 176

9. Zero Entry at 11:15

Room	Class Enrollment	Alternative Location
IV 120	206	0
OH 155	140	HOB-14 cap 212 (Same college)

10. Zero Entry at 12:20

Room	Class Enrollment	Alternative Location
IV 120	248	0
OH 155	114	HOB-14 cap 212 (Same college)

** A feasible alternative that exceeds by only 4% the 80% occupancy definition of "full".

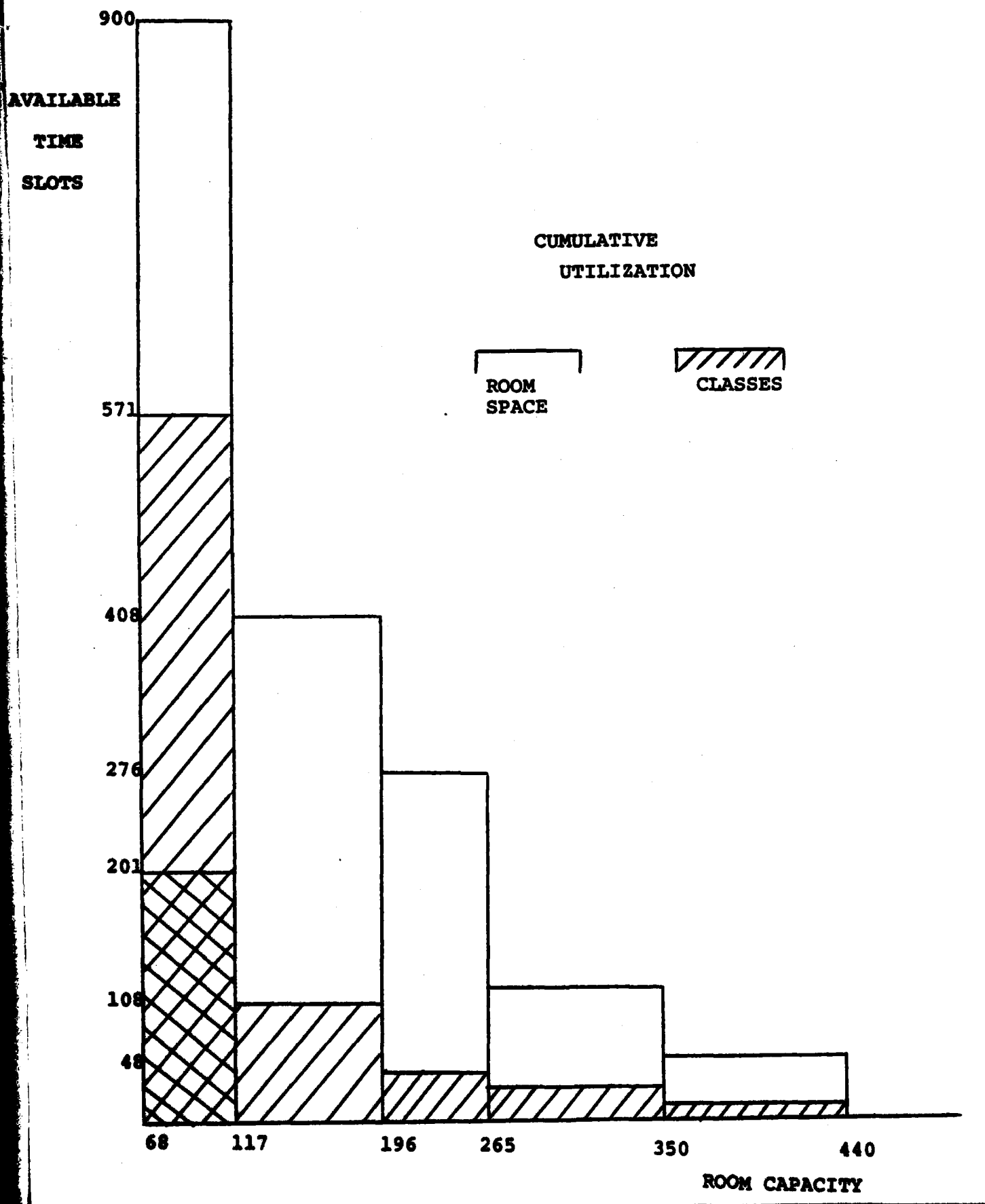
at that time. Finally, and most important, it gives alternative rooms which could feasibly be used for that particular class, thus opening up one or more rooms in that period and eliminating the "shortage". Again, in every case, a class occupying one of the large classrooms that are used to capacity for a particular location, time and day, is small enough to be shifted to a smaller classroom within the same location group, and in 7 out of 10 cases within the same college.

In only two cases would it be necessary to violate the assumption that 80% constitutes "full" capacity or occupancy. One of these cases results in an 84% occupancy rate and the other in a 90% occupancy rate. Rare, or perhaps even occasional, violations of the 80% constraint should be acceptable.

A more general observation is that the "shortages" appear only in the two largest size groups and only at the more popular times of the day, that is, 9:05, 10:10, 11:15 and 12:20. In fact, the general trend shown in all the tables, no matter what the breakdown, is that these popular time periods are much more heavily used; the 8:00 time period and the later afternoon periods are frequently empty.

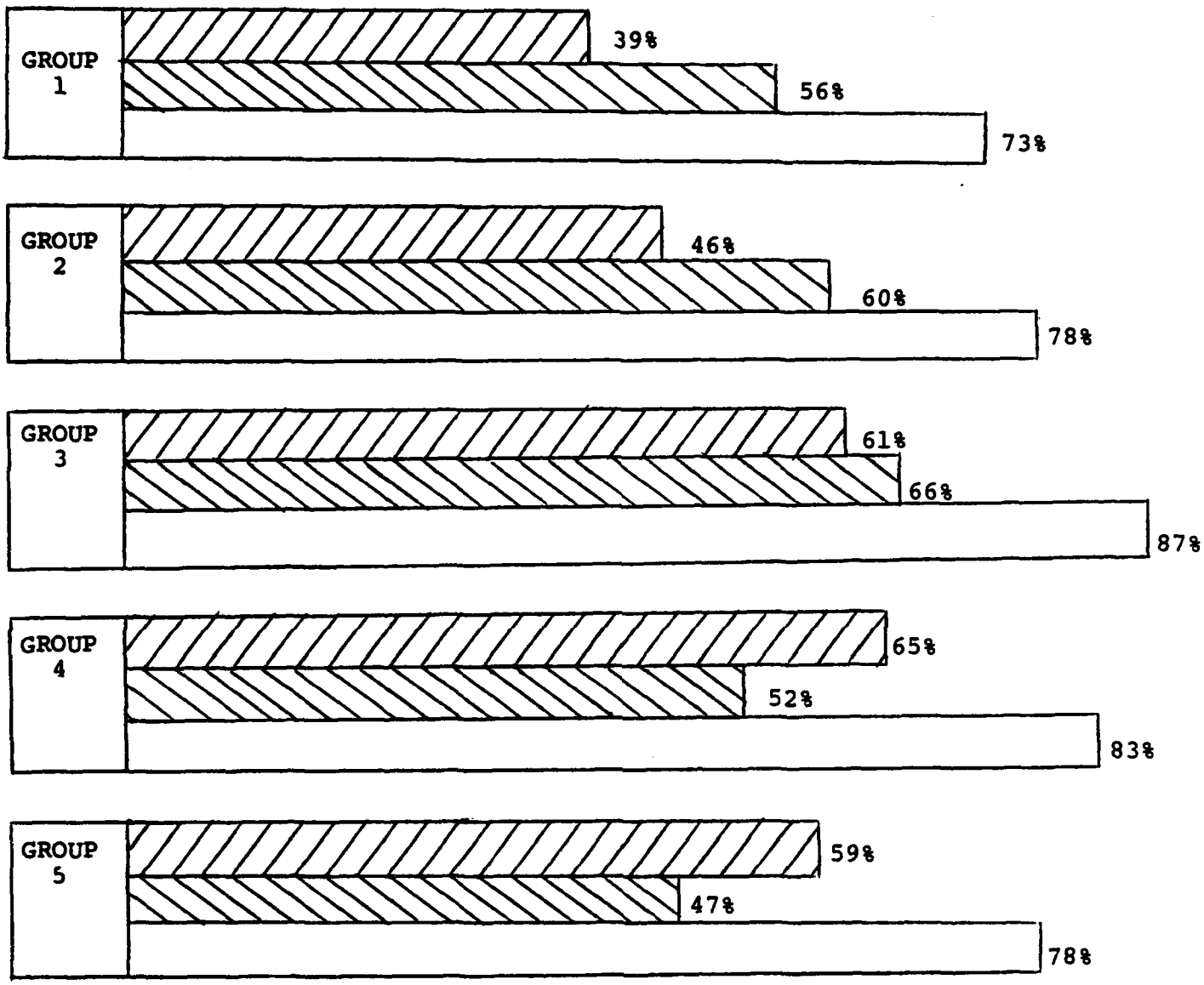
These facts lead to the inevitable conclusion that there is no physical shortage of large classrooms and lecture halls at Cornell. This conclusion is dramatically demonstrated in Figures III and IV. Figure III graphically shows the overall utilization rates of large classrooms at Cornell. The room space bars represent the product of the total number of rooms in that capacity group or larger and the available "time slots" in an academic week. A "time slot" is a period during which a typical class could be scheduled. For example, Monday, Wednesday, Friday at 9:05 is one such time slot. There are 12 such slots in a week. Therefore, the height of each column is 12 times the number of rooms in that capacity group and all larger groups. For example, there are five rooms with capacities ranging from 265 to 350 and four rooms with capacities ranging from 350 to 440, so the room space bar height for 265 to 350 is 108 (9 x 12). Then, the area of each bar that is shaded represents the actual number of cumulative classes corresponding to that capacity and larger that are currently scheduled. As can be seen from the chart, the large classrooms are hardly full. The left-most column depicts the overall situation. For 75 large classrooms, there are 900 available time slots, into which only 571 classes are currently scheduled. However, 571 is the number of classes with capacities of zero to

FIGURE III


900
AVAILABLE
TIME
SLOTS
571
408
276
201
108
48
CUMULATIVE
UTILIZATION
ROOM
SPACE
CLASSES
68
117
196
265
350
440
ROOM CAPACITY

OCCUPANCY DATA

FIGURE IV



440 that are scheduled. If the zero to 59 capacity classes (classes that could be scheduled in smaller classrooms not considered) are not included, the number of classes scheduled into the 900 available slots is only 201. This is indicated by the double hatched area in Figure III. So, while this figure doesn't match class enrollments to room sizes, it shows that overall, the large classrooms are used less than one-quarter of the time.

Figure IV incorporates overall occupancy and utilization rate to show the vacancy of Cornell's large classrooms. For each size group, the top bar represents the percentage of seats empty when an average-sized class is in session in a room (one minus the occupancy rate). The middle bar is the percentage of rooms empty, or one minus the utilization rate for a typical week. The lower bar is the overall percentage of empty seats in the large classrooms. It is equal to one minus the product of the utilization and occupancy rates. For each size group, there are over 70% of the seats in those classrooms empty during the week. This does not indicate a physical shortage. However, several underlying reasons are revealed which may have originated this belief.

VI. REASONS FOR PERCEIVED SHORTAGES

These reasons do not have actual data to support them.

Being subjective, they cannot be readily ananyzed using a defined rate such as a utilization or occupancy rate. However, their validity derives from the feelings and perceptions of the people most closely associated with the classroom scheduling duties. Time and again, these points were brought up and confirmed by several of the individual college registrars.

(1) Communication Problems -- While there is informal communication among some individual college registrars, there is a general lack of communication between the college registrars and the central registrar. It is quite common for room assignments to be changed early in the semester because pre-registration data poorly estimates actual enrollments. Classes are often added, cancelled, or moved to different size rooms. Under the current system, this information may not be fed back to the central registrar.

(2) Preference Problems -- There is an understandable desire by the faculty to teach as close to their offices as possible. Perhaps the most significant argument is to save professors' time by minimizing the distance between classes and offices. This is valid up to a point, i.e., the professor's office and class should be in the same location group. Also, specific consideration should be given to the few situations in which bulky or heavy teaching materials must be transported. While these reasons, and perhaps others, do justify scheduling classes close to faculty

offices whenever possible, they do not justify the expense of new classroom construction. Unnecessarily restrictive preferences, such as a professor insisting on teaching in the same building and on the same floor as his office, as well as at a popular hour, must take a back seat when necessity and efficiency dictate.

(3) Set Schedule Pattern -- At Cornell, students and faculty conform to a particular schedule pattern, namely a 9:05 to 12:20 academic day. Students typically do not schedule classes until 9 o'clock in the morning if they can help it, and prefer to be finished by 1 P.M. Therefore, classrooms in general (including large classrooms) are relatively under utilized during the early morning and afternoon hours.

(4) Pre-registration Problem -- Although pre-registration is the means used for estimating course enrollments, the pre-registration figures are not good estimates of actual enrollments, which can be determined only after about three weeks into the semester. Reasons for this are as follows: 1) It has been a long-time practice of students to "shop around" for courses during the first three weeks of the semester. This creates a significant shifting of enrollment sizes among all courses. Consequently, some sections (classes) may become unnecessarily small and some become too

big for their scheduled classrooms; and 2) Graduate students upset the early scheduling process because they do not pre-register. They are only required to register for classes within four weeks of the semester's beginning. However, since graduate students usually enroll in higher level courses which typically have lower enrollments they create only a minor problem.

(5) Subdivision Trend -- For the past few years at Cornell, there has been a trend towards the breaking up of large sections into smaller sections. (This may account for the low occupancy rates in large classrooms). Should this trend continue, large classrooms should, in addition, become less and less utilized. However, there is no guarantee that this subdivision will persist.

VII. SCHEDULING

The previous analysis points out that classrooms are not well utilized at Cornell. One option is to increase the utilization of classrooms by centralizing the scheduling process. Various scheduling schemes can be developed and tested for their effectiveness.

This section discusses a possible scheduling scheme that could be used for such a purpose. The scheme presented will consider faculty preferences. It aims at developing a

computer program that will aid in the assignment of courses to available classroom space. The computer program is also intended to reduce the time and effort expended in manually making (and changing) classroom assignments.

Before scheduling can begin, the scheduler must determine what objectives are to be used. Some objectives that could be considered when assigning classes to classrooms are:

(1) Minimize the number of classrooms used;

(2) Maximize the utilization of all rooms dedicated to teaching;

(3) Satisfy faculty room, day, and period preferences; and

(4) Maximize the probability of having some space available to schedule irregular or unforseen events.

To be able to meet or even attempt such objectives, the following information is essential to the scheduler:

(1) How many sections are to be scheduled;

(2) How many hours per week are needed for each class or section;

(3) What days each class will meet (the "day preference," i.e., M, W, F);

(4) The number of rooms dedicated to teaching purposes;

(5) The size of the classrooms available;

(6) The locations of the classrooms available;

(7) The physical characteristics of all classrooms;

(8) The maximum number of hours classes will be scheduled each day; and

(9) The room, time, and period preference of all professors (Only one preference is considered).

Certain constraints must also be satisfied when assigning classes to classrooms. They are:

(1) No class conflicts are allowed, i.e., at most one class can be scheduled in a given room at a single time;

(2) A class cannot be assigned to a room if the room does not have adequate seating capacity or certain necessary physical characteristics;

(3) Small classes will not be allowed to meet in very large classrooms;

(4) The same section will occupy the same period on all days it is scheduled to meet; and

(5) Each class must not be scheduled "too far" from its respective department;

(6) Pairs of courses known to be taken by the same students in the same term should not be scheduled at the same time.

SCHEDULING ALGORITHM I

This scheduling algorithm was developed by researchers at the Health Systems Research Division at the University of Florida.[1] In this model, room, time and day preferences are given to the scheduler and a schedule is to be produced that maximizes total professor satisfaction. The algorithm explanation includes some terms that are defined as follows:

(1) Priority -- sequence in which classes are to be scheduled;

(2) Feasible room -- any room which is large enough;

(3) Satisfactory room -- a feasible room not larger than the class size plus some specified amount;

(4) Closest period -- within one period of the requested time;

(5) Next closest period -- two periods from the requested time; and

(6) Farthest period -- 3 periods from the requested time.

The algorithm schedules all classes in priority order. This priority order is based on subjective judgment, seniority, or some other criteria for evaluating the relative importance among departments and professors. Each professor gives two choices of room, day, and time. Classes are scheduled to rooms by priority, in the following manner:

1 For University of Florida Study, although the complete report was not available to us, its basic procedures, as described by Professor Lee Schruben, are given below.

Step 1: A check is made made to see if the first request is available. If it is, the class is scheduled to the room, time and day of its first request. If the first request is not available, the second choice is evaluated.

Step 2: If request two is available, and the class was not assigned in Step 1, the class is assigned to the room, time, and day of this choice. If the second request is not available, then an attempt will be made to schedule the next class on the priority listing.

The above steps are performed for each class. Some classes may not yet be scheduled by that initial process.

Now Part Two of the algorithm is begun. Room time slot for unassigned classes are checked in the following order until an opening is found:

(1) Closest period for a satisfactory room.

(2) Closest period for a feasible room.

(3) Next closest period for a satisfactory room.

(4) Next closest period for a feasible room.

(5) Farthest period for a satisfactory room.

(6) Farthest period for a feasible room.

If a class is not scheduled at the completion of Step 6, the professor is notified and given other day, room and period choices which are still available at the end of

the scheduling phase.

This algorithm is mentioned as a possible method for increasing classroom utilization and occupancy, should the university deem that objective desirable. Finding solutions to such a scheduling problem would be an ideal project for further study by the Operations Research Department.

VIII. RECOMMENDATIONS

One of the most difficult tasks encountered in completing this project was accurate data collection. There exist many informational discrepancies in the data among the field study information sources. Classroom information entered in the university's computerized space inventory file often did not match registrar's records. These inconsistencies in the data should be corrected in the official records. These records should be updated to reflect any changes in classroom data and room assignment information. If changes do occur, it should be the responsibility of each college registrar to update the assignments and submit changes to the central registrar. Furthermore, rooms are occasionally renovated during the semester, which may change the room's capacity, function or quality. In such cases, the college registrars having

jurisdiction over those rooms should report all physical changes to the central registrar. If all of this information was fed back to the central registrar correctly, this would enable the university registrar to build one central data base on university-wide space utilization.

Currently, there is no systematic method for updating information. A manageable, accurate data updating scheme is urgently needed. A complete update of the space inventory file would require printing out classroom summaries, sending them out to the colleges, and get them updated and returned. This updating procedure should be done on a regular basis, at least once every semester. Updating the classroom assignments is slightly more involved because this requires the matching of many courses to classrooms. Sets of classroom time table forms could be sent to the college registrars, then returned indicating any changes in classroom schedules. This procedure should be done twice every semester, once immediately following the add/drop period expiration, and the other at the end of the semester. Using this regular updating procedure, information in the computer file system can be kept current and thus a central data base on university-wide space utilization would be built. The key to making such a system successful is ensuring its facility. If the updating and reporting

procedures were standardized and were not inconvenient for the college registrar to implement, the system could solve the information flow problems that currently exist.

Another recommendation is that the college registrars be given more authority to assign rooms which they think best. The general consensus of a meeting held with the college registrars was that, if they could assign more flexiby, most, if not all, of the perceived shortages would disappear.

In summary, an accurate, functional data base is a prerequisite for being able to answer questions such as the one which generated this study. Then, a review of certain present university policies and attitudes is necessary. Is the value of being able to please all the people (both students and professors) all the time worth the cost of creating expensive additional classroom space?

If the answer to that question is no, then the recommended changes are in order. Additional study into just how the existing plant could be most efficiently used to reduce further building and facility costs, would be a worthy topic of another project.

APPENDIX A

LIST OF LARGE CLASSROOMS

BUILDING	BUILDING CODE	ROOM	CAPACITY	TYPE	COLLEGE
*Rockefeller	RF	A	468	F	AS
Ives	IV	120	440	F	IL
*Uris	UH	G1	428	F	AS
*Baker	BR	200	400	F	AS
Van Rens	VR	167	350	F	HE
Olin	OH	155	335	F	EN
Plant Science	PS	233	327	F	AG
*Warren	WN	45	323	F	AG
Morrison	MN	146	314	F	AG
*Stimson	SN	G25	265	F	AS
Statler	SR	334	252	F	HL
*Upson	UP	B-17	248	F	EN
Phillips	PH	101	228	F	EN
*Kimball	KL	B-11	226	F	EN
Olin	OH	255	224	F	EN
Van Rens	VR	158	220	F	HE
Goldwin Smith	GS	HEC	217	F	AS
Goldwin Smith	GS	KAU	217	F	AS
*Hollister	HO	B-14	212	F	EN
Stocking	SK	204	210	F	AG
Rockefeller	RF	B	206	F	AS
Goldwin Smith	GS	D	205	F	AS
Riley-Robb	RR	125	200	F	AG
Bradfield	BF	101	196	F	AG
Ives	IV	110	192	F	IL
Tjaden	TJ	115	180	F	AR
Statler	SR	434	170	M	HL
Caldwell	CD	100	150	F	AG
Warren	WN	131	150	F	AG
Warren	WN	231	150	F	AG
Olin	OH	165	140	F	EN
Statler	SR	117	133	F	HL
Statler	SR	217	133	F	HL
McGraw	MG	165	125	M	AS
Morrison	MN	163	117	F	AG
Phillips	PH	219	116	F	EN
Van Rens	VR	N207	115	F	HE
Ives	IV	215	112	M	IL
Warren	WN	145	112	F	AG
Warren	WN	245	112	F	AG
Warren	WN	345	112	F	AG
Roberts	RT	131	110	F	AG
*Rockefeller	RF	G	108	F	AS
*Rockefeller	RF	F	106	F	AS

TABLE I

LIST OF LARGE CLASSROOMS

BUILDING	BUILDING CODE	ROOM	CAPACITY	TYPE	COLLEGE
Baker	BR	219	104	F	AS
Baker	BR	135	104	F	AS
Baker	BR	119	104	F	AS
Baker	BR	335	104	F	AS
Thurston	TH	203	102	F	EN
Thurston	TH	105	102	F	EN
East Roberts	ER	222	100	F	AG
*Rockefeller	RF	D	100	F	AS
*Morrison	MN	82	98	M	AG
*East Sibley	ES	157	97	M	AR
*Stimson	SN	G1	96	F	AS
Olin	OH	145	94	F	EN
Ives	IV	117	90	M	IL
Ives	IV	213	90	M	IL
Goldwin Smith	GS	225	89	F	AS
Statler	SR	437	86	M	HL
Statler	HO	110	84	M	EN
Plant Science	PS	143	80	M	AG
Riley-Robb	RR	105	80	M	AG
Uris	UH	G94	80	M	AS
Goldwin Smith	GS	156	76	F	AS
*Morrison	MN	167	75	M	AG
*Plant Science	PS	37	75	M	AG
Statler	SR	438	73	M	HL
Van Rens	VR	N225	70	M	HE
Van Rens	VR	NG02	70	M	HE
Bradfield	BF	108	70	M	AG
Rockefeller	RF	103	70	F	AS
Hollister	HO	206	69	M	EN
Morrill	ML	106	69	F	AS
Stocking	SK	119	68	M	AG

F = Fixed Seat
M = Movable Seat
AG = Agriculture and Life Sciences
AR = Architecture
AS = Arts and Sciences
EN = Engineering
HE = Human Ecology
HL = Hotel
IL Industrial and Labor Relations

TABLE I

ROOM UTILIZATION CHART

DAY MONDAY

ROOM	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
RF A			●		●		●		WN 145								
IV 120		●	●	●	●				WN 245		●	●	●	●	●		
UH G1		●	●	●	●	●			WN 345	●	●	●	●				
BR 200	●	●	●	●	●				RT 131	●	●	●					
VR 167	●	●	●						RF G				●				
OH 155		●	●	●	●				RF F		●	●	●				
PS 233		●		●	●				BR 219	●		●	●	●		●	●
WN 45		●	●	●	●	●			BR 135			●	●		●	●	
MN 146	●	●		●					BR 119		●	●	●		●		
SN G25	●		●		●				BR 335		●	●	●	●			
SR 334		●	●	●	●	●			TH 203		●		●	●	●	●	●
UPB-17		●	●	●	●	●	●		TH 205		●	●	●		●	●	●
PH 101		●	●	●	●				ER 222		●	●	●	●			
KLB-11		●	●	●	●				RF D		●		●	●	●		
OH 255		●	●	●	●				MN 82						●	●	●
VR 158			●		●				ES 157		●	●	●				
GS HEC		●	●	●	●		●	●	SN G1		●	●	●				
GS KAU			●	●		●			OH 145			●	●		●		
HOB-14		●	●			●			IV 117		●	●	●	●	●	●	●
SK 204			●						IV 213		●	●	●	●	●	●	●
RF B		●		●			●	●	GS 225		●	●			●		
GS D		●	●	●	●				SR 437			●	●			●	●
RR 125	●								HO 110		●	●	●		●	●	
BF 101		●	●	●					PS 143		●	●	●	●	●	●	●
IV 110			●	●	●	●			RR 105	●	●		●	●	●	●	●
TJ 115		●	●						UH G94		●			●		●	
SR 434				●	●	●			GS 156		●	●	●		●		
CD 100			●						MN 167								
WN 131	●	●	●	●	●	●	●		PS 37	●	●	●	●	●			
WN 231	●	●	●	●	●	●			SR 438	●	●		●			●	●
OH 165		●	●	●	●	●			VRN225			●	●				
SR 117		●	●	●	●	●	●	●	VRNG02		●	●		●	●	●	●
SR 217		●	●			●	●	●	BF 108	●	●	●	●		●	●	●
MG 165		●	●	●	●	●			RF 103				●	●	●		
MN 163		●				●	●	●	HO 206			●			●	●	
PH 219		●	●	●	●		●	●	ML 106	●	●	●	●	●	●	●	●
VRN207		●	●	●	●	●	●	●	SK 119		●	●	●		●	●	●
IV 215		●	●		●	●											

TABLE III

ROOM UTILIZATION CHART

DAY TUESDAY

ROOM	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
RF A		●		●					WN 145	●		●	●				
IV 120		●		●					WN 245		●	●	●	●			
UH G2		●		●			●	●	WN 345	●	●	●	●		●		
BR 200		●	●	●	●		●		RT 131	●	●	●					
VR 167				●			●		RF G	●	●	●	●	●		●	
OH 155			●						RF F		●	●	●			●	
PS 233		●	●	●					BR 219	●	●	●		●		●	●
WN 45		●	●	●					BR 135	●	●	●	●	●		●	●
MN 146		●	●	●					BR 119		●	●		●	●		
SN G25									BR 335		●	●		●			
SR 334			●			●			TH 203	●	●	●	●		●	●	●
UPB-17	●		●		●				TH 205			●	●	●	●	●	
PH 101		●	●	●					ER 222			●	●		●		
KLB-11		●		●					RF D			●	●			●	●
OH 255	●	●							MN 82		●		●		●	●	●
VR 158			●	●					ES 157		●	●	●	●	●	●	
GS HEC		●	●	●	●	●	●	●	SN G1				●	●	●	●	●
GS KAU					●	●			OH 145	●	●		●	●	●	●	●
HOB-14		●	●	●	●				IV 117	●	●	●	●				
SK 204		●	●						IV 213	●	●	●	●			●	●
RF B		●		●					GS 225	●	●	●	●	●	●		
GS D			●	●	●				SR 437							●	●
RR 125						●			HO 110	●	●	●	●				●
BF 101		●		●	●				PS 143		●		●	●	●	●	●
IV 110			●	●		●	●		RR 105		●	●	●		●	●	●
TJ 115		●		●	●		●	●	UH G94	●	●	●	●	●	●		●
SR 434	●	●			●	●	●	●	GS 156	●		●	●	●	●	●	●
CD 100		●	●	●					MN 167								
WN 131	●			●	●	●	●	●	PS 37	●	●		●			●	●
WN 231	●	●		●	●	●			SR 438	●	●		●	●		●	●
OH 165					●				VRN225			●	●	●	●	●	●
SR 117	●	●	●	●		●	●	●	VRNG02		●	●	●			●	●
SR 217			●	●		●	●	●	BF 108	●	●	●	●		●	●	●
MG 165			●	●	●	●	●	●	RF 103	●	●	●	●	●		●	●
MN 163		●	●			●	●	●	HO 206	●	●	●	●				
PH 219				●	●	●			ML 106	●	●	●	●	●		●	
VRN207			●	●	●	●			SK 119			●	●				
IV 215	●	●		●	●	●	●										

TABLE IV

ROOM UTILIZATION CHART

DAY WEDNESDAY

ROOM	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
RF A			●		●				WN 145						●	●	
IV 120		●	●	●	●				WN 245		●	●	●		●	●	●
UH G1		●	●	●	●	●			WN 345	●	●	●	●	●	●		
ER 200		●	●	●	●				RT 131	●	●	●	●	●			
VR 167	●	●	●						RF G				●		●	●	●
OH 155		●	●	●	●				RF F		●	●	●				
PS 283		●		●	●				BR 219	●		●	●	●		●	
WN 45		●	●	●	●	●			BR 135			●	●	●	●		
MN 146	●	●	●	●					BR 119		●	●	●		●		
SN G25	●		●						BR 335		●	●	●	●			
SR 334		●	●	●	●	●	●		TH 203		●		●		●	●	●
UPB-17		●	●	●	●				TH 205		●		●		●	●	●
PH 101		●	●	●	●				ER 222		●	●	●		●		
KLB-11		●	●	●	●				RF D		●	●	●	●	●		
OH 255		●	●	●	●				MN 82						●	●	●
VR 158			●						ES 157		●	●	●				
GS HEC		●	●	●	●				SN G1		●	●	●				
GS KAU			●	●	●				OH 145			●	●		●		
HOE-14		●	●			●			IV 117		●	●	●	●	●	●	●
SK 204			●						IV 213		●	●	●	●	●	●	●
RF B		●		●					GS 225		●	●	●		●	●	
GS D		●	●	●	●				SR 437							●	●
RR 125	●								HO 110		●	●	●		●	●	
BF 101		●	●	●		●			PS 143		●	●	●	●			
IV 110			●	●	●	●			RR 105	●	●		●	●	●	●	●
TJ 115									UH G94		●		●	●	●	●	●
SR 434				●	●				GS 156		●	●	●		●		
CD 100			●	●		●			MN 167								
WN 131	●	●	●	●	●	●			PS 37	●	●	●	●			●	
WN 231	●	●	●	●	●	●			SR 438	●	●						
OH 165		●	●	●	●	●			VRN225			●	●				
SR 117		●	●	●	●	●			VRNG02	●	●	●			●		●
SR 217		●	●	●	●				BF 108	●	●	●	●	●	●	●	●
MG 165		●	●	●	●	●			RF 103				●	●	●	●	●
MN 163		●							HO 206			●			●	●	
PH 219		●	●	●	●		●	●	ML 106	●	●	●		●	●	●	
VRN207		●	●	●	●	●	●	●	SK 119		●	●	●				
IV 215		●	●		●	●	●	●									

TABLE V

ROOM UTILIZATION CHART

DAY THURSDAY

ROOM	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
RF A		●		●					WN 145	●		●	●			●	●
IV 120		●		●					WN 245		●	●	●				
UH GL		●		●			●	●	WN 345	●	●	●	●				
BR 200		●	●	●	●		●		RT 131		●	●		●	●	●	●
VR 167				●			●		RF G	●	●	●	●	●			
OH 155			●						RF F		●	●	●				
PS 233		●	●	●					BR 219		●	●		●			
WN 45		●	●	●					BR 135	●	●	●	●	●		●	●
MN 146		●	●	●					BR 119		●	●		●			
SN G25									BR 335		●	●		●			
SR 334			●						TH 203	●	●	●	●		●	●	●
UPB-17			●		●				TH 205			●	●	●	●	●	
PH 101		●	●	●					ER 222			●	●	●	●		
KLB-11		●		●					RF D			●	●		●	●	●
OH 255	●	●							MN 82		●		●				
VR 158			●	●					ES 157		●	●	●	●	●	●	●
GS HEC		●	●	●	●	●	●	●	SN G1				●	●	●	●	●
GS KAU					●	●			OH 145								
HOB-14		●	●	●	●				IV 117	●	●	●	●				
SK 204		●	●						IV 213	●	●	●	●			●	●
RF B		●		●					GS 225			●	●	●	●		
GS D			●	●	●				SR 437							●	●
RR 125	●								HO 110								
BF 101		●		●	●				PS 143		●		●	●	●	●	●
IV 110			●	●		●	●		RR 105		●	●	●				
TJ 115		●		●	●		●	●	UH G94	●	●	●	●	●	●		●
SR 434		●					●	●	GS 156	●		●	●	●	●	●	●
CD 100		●	●	●					MN 167								
WN 131	●			●	●	●	●	●	PS 37	●	●	●	●				
WN 231				●	●				SR 438	●	●		●	●		●	●
OH 165					●				VRN225			●	●	●	●	●	●
SR 117	●	●					●	●	VRNG02		●	●	●			●	●
SR 217			●			●			BF 108	●	●	●	●	●	●	●	●
MG 165			●	●	●	●	●	●	RF 103	●	●	●	●	●			
MN 163		●	●			●	●	●	HO 206	●	●	●	●			●	●
PH 219				●	●	●	●		ML 106	●	●	●	●	●	●	●	
VRN207					●	●			SK 119			●	●				
IV 215	●	●		●	●	●	●										

TABLE VI

ROOM UTILIZATION CHART

DAY FRIDAY

ROOM	1	2	3	4	5	6	7	8
RF A			●		●			
IV 120		●	●	●	●			
UH G1			●		●	●		
BR 200	●	●	●					
VR 167	●	●	●					
OH 155		●	●	●	●			
PS 233		●		●	●			
WN 45		●	●	●	●			
MN 146	●	●	●	●				
SN G25	●		●					
SR 334		●	●	●	●			
UPB-17		●	●	●	●	●	●	
PH 101		●	●	●				
KLB-11			●		●			
OH 255		●						
VR 158	●		●					
GS HEC		●	●	●	●			
GS KAU			●	●		●		
HOB-14		●				●		
SK 204			●	●				
RF B								
GS D		●	●	●				
RR 125	●							
BF 101		●	●			●		
IV 110			●					
TJ 115							●	●
SR 434		●	●					
CD 100			●	●				
WN 131	●	●	●	●	●			
WN 231	●	●	●	●	●			
OH 165		●	●	●	●			
SR 117			●	●	●		●	●
SR 217			●				●	
MG 165		●		●	●	●		
MN 163		●						
PH 219		●	●	●	●		●	●
VRN207		●	●	●	●	●		
IV 215		●				●	●	●

	1	2	3	4	5	6	7	8
WN 145								
WN 245		●	●	●	●	●	●	●
WN 345	●	●	●	●				
RT 131	●	●	●					
RF G				●				
RF F		●	●	●				
BR 219	●		●	●	●		●	
BR 135			●	●	●	●		
BR 119		●	●	●				
BR 335		●	●	●	●			
TH 203		●	●		●	●		
TH 205		●	●	●	●			
ER 222		●	●	●				
RF D		●	●	●		●		
MN 82								
ES 157		●	●	●				
SN G1		●	●	●				
OH 145			●	●				
IV 117		●	●					
IV 213			●	●		●	●	
GS 225		●	●	●		●		
SR 437		●	●	●				
HO 110		●	●	●				
PS 143			●	●		●	●	
RR 105	●			●	●			
UH G94		●	●	●	●		●	
GS 156		●		●		●		
MN 167								
PS 37		●	●	●	●			
SR 438			●					
VRN225					●	●		
VRNG02		●	●			●		
BF 108	●	●	●	●				
RF 103				●	●	●	●	●
HO 206	●	●	●	●	●		●	
ML 106	●	●	●	●	●	●		
SK 119		●	●			●	●	●

TABLE VII

APPENDIX B

```
TOF:
 SECFILE:PROCEDURE OPTIONS(MAIN);
 /*****************************************************/
 /*                                                   */
 /*   THE FOLLOWING PROGRAM IN PL/I READS THE COURSE  */
 /* MEETING TIME FILE TAPE AND REFORMAT THE FILE AND  */
 /* PRINT OUT THE REFORMAT FORM OF THE RECORDS IN THE */
 /* COURSE MEETING TIME FILE.                         */
 /*                                                   */
 /*****************************************************/
   DECLARE TAPE FILE RECORD, /* COURSE MEETING TIME ON TAPE   */
           REPORT FILE PRINT;/* PRINT-OUT FILE ---- LISTING   */
   DCL IN CHAR(180);         /* IN CONTAINS ORIGONAL RECORDS  */
   DCL 1 SEC DEFINED IN,     /* SEC IS THE FORMAT OF THE      */
         2 COL_DEPT_NUM  CHAR(5), /* ORIGONAL RECORDS         */
         2 COURSE_NUM    CHAR(3),
         2 SECTION_TYPE  CHAR(1),
         2 SECTION_NUM   CHAR(2),
         2 YEAR          CHAR(2),
         2 TERM          CHAR(1),
         2 MEETING_TIME  CHAR(6),
         2 JUNK1         CHAR(32),
         2 DATE_TIME     CHAR(15),
         2 MEETING_PLACE,
          3 BUILDING     CHAR(2),
          3 ROOM         CHAR(4),
         2 JUNK2         CHAR(69),
         2 MEETING_CODE  CHAR(3),
         2 JUNK3         CHAR(35);
   DCL OUT CHAR(120);          /* OUT CONTAINS RECORD TO BE PRINTED */
   DCL 1 PRT_OUT DEFINED OUT,   /* PRT_OUT IS THE FORMAT OF THE RE-  */
         2 COL_DEPT_NUM  CHAR(5),/* FORMATED COURSE MEETING TIME FILE */
         2 FILL1         CHAR(2),
         2 COURSE_NUM    CHAR(3),
         2 FILL2         CHAR(2),
         2 SECTION_NUM   CHAR(2),
         2 FILL3         CHAR(2),
         2 SECTION_TYPE  CHAR(1),
         2 FILL4         CHAR(2),
         2 YEAR          CHAR(2),
         2 TERM          CHAR(1),
         2 FILL5         CHAR(6),
         2 MEETING_TIME  CHAR(6),
         2 FILL6         CHAR(6),
         2 MEETING_PLACE,
          3 BUILDING     CHAR(2),
          3 ROOM         CHAR(4),
         2 FILL7         CHAR(6),
         2 MEETING_CODE  CHAR(3),
         2 FILL8         CHAR(6),
         2 DATE_TIME     CHAR(15),
         2 FILL9         CHAR(44);
       OPEN FILE (TAPE);
       OPEN FILE (REPORT) PRINT LINESIZE(120) PAGESIZE(60);
       ON ENDFILE (TAPE) GO TO STOP;
       /* READ IN A RECORD FROM COURSE MEETING TIME FILE */
```

```
    LOOP: READ FILE (TAPE) INTO (IN);
          PRT_OUT=SEC, BY NAME;    /* FORMAT THE RECORD */
        /* PRINT THE RECORD OUT */
          PUT FILE (REPORT) EDIT (OUT) (SKIP,A(120));
          GO TO LOOP;
    STOP: CLOSE FILE (TAPE);
          CLOSE FILE (REPORT);
          END SECFILE;
EOF:
-
```

```
TOF:
  LRFILE:PROCEDURE OPTIONS(MAIN);
  /*************************************************************/
  /*                                                           */
  /* THE FOLLOWING PROGRAM IN PL/I READS THE COURSE MEETING    */
  /* TIME FILE AND THE  LARGE CLASSROOM FILE AND EXTRACTS ALL  */
  /* SECTIONS THAT ARE ASSIGNED TO LARGE CLASSROOM.            */
  /* (LARGE CLASSROOMS HAVE 68 OR MORE SEATS.)                 */
  /*                                                           */
  /*************************************************************/
     DECLARE TAPE FILE RECORD, /* COURSE MEETING TIME ON TAPE */
             LRFL FILE PRINT;  /* PRINT-OUT FILE              */
     DCL IN CHAR(180);         /* IN CONTAINS ORIGINAL RECORDS*/
     DCL 1 SEC DEFINED IN,     /* SEC IS THE FORMAT OF THE    */
                               /* ORIGINAL RECORDS            */
           2 COL_DEPT_NUM    CHAR(5),
           2 COURSE_NUM      CHAR(3),
           2 SECTION_TYPE    CHAR(1),
           2 SECTION_NUM     CHAR(2),
           2 YEAR            CHAR(2),
           2 TERM            CHAR(1),
           2 MEETING_TIME    CHAR(6),
           2 JUNK1           CHAR(32),
           2 DATE_TIME       CHAR(15),
           2 MEETING_PLACE,
            3 BUILDING       CHAR(2),
            3 ROOM           CHAR(4),
           2 JUNK2           CHAR(46),
           2 ENROL           CHAR(4),
           2 JUNK3           CHAR(19),
           2 MEETING_CODE    CHAR(3),
           2 JUNK4           CHAR(35);
     DCL OUT CHAR(80);            /* OUT CONTAINS RECORD TO BE PRINTED */
     DCL 1 PRT_OUT DEFINED OUT, /* PRT_OUT IS THE FORMAT OF THE LRFL */
                               /* FILE'S FORMAT                     */
           2 COL_DEPT_NUM    CHAR(5),
           2 FILL1             CHAR(2),
           2 COURSE_NUM      CHAR(3),
           2 FILL2           CHAR(2),
           2 SECTION_NUM     CHAR(2),
           2 FILL3           CHAR(2),
           2 SECTION_TYPE    CHAR(1),
           2 FILL4           CHAR(2),
           2 YEAR            CHAR(2),
           2 TERM            CHAR(1),
           2 FILL5           CHAR(4),
           2 MEETING_TIME    CHAR(6),
           2 FILL6           CHAR(4),
           2 MEETING_PLACE,
            3 BUILDING       CHAR(2),
            3 ROOM           CHAR(4),
           2 FILL7           CHAR(3),
           2 ROOM_CAP        CHAR(3),
           2 FILL8           CHAR(3),
           2 ROOM_TYPE       CHAR(1),
           2 FILL9           CHAR(3),
```

```
        2 MEETING_CODE    CHAR(3),
        2 FILLIO           CHAR(3),
        2 DATE_TIME       CHAR(15),
        2 ENROL           CHAR(4);
     DCL REC CHAR(80);
    DCL 1 FACL DEFINED REC,
        2 JUNK1            CHAR(2),
        2 PLACE,
          3 BUILDING      CHAR(2),
          3 ROOM          CHAR(4),
        2 JUNK2           CHAR(1),
        2 ROOM_CAP        CHAR(3),
        2 JUNK3           CHAR(2),
        2 ROOM_TYPE       CHAR(1),
        2 JUNK4           CHAR(65);
       OPEN FILE (TAPE);
       OPEN FILE (LRFL) PRINT LINESIZE(80) PAGESIZE(60);
       ON ENDFILE (TAPE) GO TO AGAIN;
       ON ENDFILE (SYSIN) GO TO STOP;
       /* READ IN A RECORD FROM COURSE MEETING TIME FILE */
    LOOP1: GET EDIT (REC) (COL(1),A(80));
           PUT SKIP LIST (REC);
    LOOP2: READ FILE (TAPE) INTO (IN);
           IF (FACL.PLACE.BUILDING=SEC.MEETING_PLACE.BUILDING &
               FACL.PLACE.ROOM=SEC.MEETING_PLACE.ROOM)
              THEN DO; PRT_OUT=SEC, BY NAME;
                       PRT_OUT=FACL, BY NAME;
                       PUT FILE (LRFL) EDIT (OUT) (SKIP,A(80));
                       END;
           GO TO LOOP2;
    AGAIN: CLOSE FILE (TAPE);
           OPEN FILE (TAPE);
           GO TO LOOP1;
    STOP:  CLOSE FILE (SYSIN);
           CLOSE FILE (TAPE);
           CLOSE FILE (LRFL);
       END LRFILE;
:OF:
```

```
TOF:
 ANALYS:PROCEDURE OPTIONS(MAIN);
 /*****************************************************************/
 /*                                                               */
 /* THE FOLLOWING PROGRAM IN PL/I READS THE (LR81) FILE , PRINTS  */
 /* OUT A TIME TABLE FOR EACH CLASSROOM, ANALYSE THE ROOM OCCUPANCY*/
 /* RATIO, THE ROOMS AND SEATS UTILIZATION RATE FOR EACH CLASSROOM */
 /* AS WELL AS FOR ALL THE LARGE CLASSROOMS.                      */
 /* (LARGE CLASSROOMS HAVE 68 OR MORE SEATS)                      */
 /*                                                               */
 /*****************************************************************/
  DCL FACL(1:81)            CHAR(80);
  DCL PERIOD(1:81,1:9,1:6) CHAR(5) INIT((4374)('     '));
  DCL CUM_USE(1:81)         FLOAT DEC INIT((81)0);
  DCL ROOM_UTI(1:81)        FLOAT DEC INIT((81)0);
  DCL OCCU_RATE(1:81)       FLOAT DEC INIT((81)0);
  DCL NUM_OCC(1:81)         FLOAT DEC INIT((81)0);
  DCL DOT                   CHAR(37);
  DCL (I,J,K,M)             FIXED DEC;
  DCL SUM                   FLOAT DEC INIT(0);
  DCL CAP                   FLOAT DEC;
  DCL REC                   CHAR(80);
  DCL TSTRING               CHAR(6);
  DCL N                     FIXED DEC;
  DCL TOTAL_UTI             FLOAT DEC;
  DCL MEETING_PLACE         CHAR(6);
  DCL ROOM_CAP              FLOAT DEC;
  DCL MEETING_DAY           FIXED DEC;
  DCL MEETING_HR            CHAR(1);
  DCL MEETING_CON           CHAR(1);
  DCL ENROL                 FLOAT DEC;
  ON ENDFILE(SYSIN) GO TO STOP;
 /* READ IN THE LARGE CLASSROOMS INFORMATION */
  DO I=1 TO 76 BY 1;
    GET EDIT(FACL(I)) (COL(1),A(80));
    PUT SKIP LIST(FACL(I));
    END;
 /* DENOTE THE OCCUPANCY OF EACH CLASSROOMS IN ONE WEEK */
  GET EDIT(MEETING_PLACE,ROOM_CAP,MEETING_DAY,MEETING_HR,MEETING_CON,
           ENROL)(COL(37),A(6),X(3),F(3),X(7),F(1),A(1),X(1),A(1),
           X(17),F(4));
  PUT SKIP LIST(MEETING_PLACE,ROOM_CAP,MEETING_DAY,MEETING_HR);
  DO I= 1 TO 76 BY 1;
    DO WHILE( MEETING_PLACE=SUBSTR(FACL(I),3,6));
             CAP=ROOM_CAP;
                    K=MEETING_DAY;
                    IF MEETING_HR='A' THEN J=1;
                    IF MEETING_HR='B' THEN J=2;
                    IF MEETING_HR='C' THEN J=3;
                    IF MEETING_HR='D' THEN J=4;
                    IF MEETING_HR='E' THEN J=5;
                    IF MEETING_HR='F' THEN J=6;
                    IF MEETING_HR='G' THEN J=7;
                    IF MEETING_HR='H' THEN J=8;
                    IF MEETING_HR='I' THEN J=9;
                    M=1;
                    IF MEETING_CON='2' THEN M=2;
                    IF MEETING_CON='3' THEN M=3;
                    IF MEETING_CON='4' THEN M=4;
```

```
                    DO N=1 TO M BY 1;
                      PERIOD(I,J+N-1,K)='*****';
                      END;
                    CUM_USE(I)=CUM_USE(I)+M;
                    NUM_OCC(I)=NUM_OCC(I)+(M*ENROL);
                    GET EDIT(MEETING_PLACE,ROOM_CAP,MEETING_DAY,
                             MEETING_HR,MEETING_CON,ENROL)(COL(37),
                             A(6),X(3),F(3),X(7),F(1),A(1),X(1),
                             A(1),X(17),F(4));
                    PUT SKIP LIST(MEETING_PLACE,ROOM_CAP,MEETING_DAY);
                    END;
          STOP:IF CUM_USE(I) > 0 THEN DO;
          ROOM_UTI(I)=CUM_USE(I);
          PUT SKIP LIST(CUM_USE(I),CAP);
                    OCCU_RATE(I)=(NUM_OCC(I)/CUM_USE(I))/CAP;
                    SUM=SUM+CUM_USE(I);
                    END;
        END;
  /* PRINT OUT TIME TABLE AND UTILIZATION MEASUREMENT */
   DOT='---------------------------------------';
   DO I=1 TO 76 BY 1;
     TSTRING=SUBSTR(FACL(I),3,6);
     PUT SKIP(6) EDIT(TSTRING) (A(6));
     PUT SKIP EDIT('   *__M__*__T__*__W__*__R__*__F__*__S__*')(A(40));
   DO J=1 TO 9 BY 1;
     PUT SKIP EDIT(J,'I',PERIOD(I,J,1),'I',PERIOD(I,J,2),'I',
                   PERIOD(I,J,3),'I',PERIOD(I,J,4),'I',PERIOD(I,J,5),
                   'I',PERIOD(I,J,6),'I')(X(1),F(1),X(1),6(A(1),A(5)),
                   A(1));
     PUT SKIP EDIT (DOT)(X(3),A);
     END;
     PUT SKIP(2) DATA(ROOM_UTI(I),OCCU_RATE(I));
     END;
  /* PRINT UTILIZATION RATE OF ALL THE LARGE ROOM AS A GROUP */
   TOTAL_UTI=SUM/76;
   PUT SKIP(4) DATA(TOTAL_UTI);
 END ANALYS;
EOF:
```